High Power Input Coupler for KEKB SC Cavity

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Abstract

For high current application of superconducting cavity, one of key component is a high power input coupler. KEKB superconducting cavities have coaxial type input couplers. The inner conductor can be applied bias voltage. RF processing with bias voltage at room temperature is very effective to suppress multipactor. So without beam processing the couplers have been operated more than 380 kW. Preparation and operation of the coupler will be described.

1 INTRODUCTION

The KEKB, an asymmetric energy double-ring electron-positron collider for B-physics, has been commissioned in December 1998. Two types of heavily-damped cavities are used in KEKB. The normal conducting cavity system (ARES) used in the low energy ring (LER) and the high energy ring (HER) and 4 superconducting cavities used in the HER. Four additional superconducting cavities will be install in HER next year. The superconducting cavities need high power input coupler to feed RF power to high current of 1.1 A.

2 KEKB INPUT COUPLER

The input coupler for KEKB superconducting cavity is almost same design as that used for TRISTAN superconducting cavities.(1) The gap of 3 mm of choke structure was changed to 4 mm to reduce the field strength at ceramic disk. One of authors pointed out for TRISTAN coupler using water cooling of inner conductor. The calculated heat transfer by radiation is 0.6 W for the electro-polished Cu inner conductor(2). This heat transfer is small and is expected almost no effect to cavity performance in case of high field of more than 10 MV/m for KEKB. The water cooling has enough cooling capacity up to 1 MW. The window of the coupler is almost same as 1MW klystrons used at TRISTAN, which have long lifetime of more than 50000 hours. So the TRISTAN coupler can be operated 1 MW principally but used up to 200 kW at TRISTAN time. So for higher power operation, the KEKB couplers need more diagnostics for precise RF processing and interlock system for operating at bad vacuum condition compared to klystrons. Three monitoring ports were set near the ceramic window to monitor vacuum pressure, electron and discharge light(arc sensor) for protection and diagnosis.

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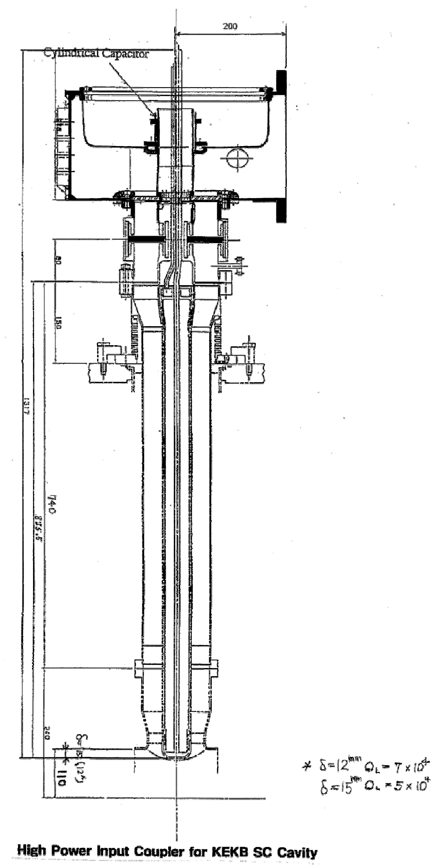

Fig.1 High power input coupler for KEKB

The KEKB couplers tested up to 800 kW[3] by the traveling wave and 300 kW totally reflected standing wave, changing phase up to half wave (in short time 500 kW which equivalently corresponding 2 MW traveling wave). In the second beam test, frequent discharge around the coupler occurred and temperature changed by cool gas flow rate affect to this trip rate. So condensed gas affects the surface condition and multipacting of the coupler occurred. Before the third test we prepared a biased type doorknob transition which can supply a bias voltage to the inner conductor of the coaxial input coupler. The biased type doorknob transition was tested at the test bench up to 300 kW standing wave changing phase half wave length and traveling wave. Between the inner

conductor and the doorknob, a capacitance of 1300 pF was inserted. The insulating material was two layer of polyimide (like as Kapton) films of 0.125 mm thick.(4)
The bias-type door-knob transitions were tested 450 kW transmission condition and 300 kW full reflection condition.
The bias voltage will be also used to suppress multipactoring in the input coupler after long term operation when multipactoring is known to reappear due to condensed gases on the outer conductor.

2 COUPLER PREPERATION

The coupler is shown in Fig. 1. The inner conductors were prepared some rinsing before RF processing. The rinsing process were followings.

1. Acetone rinsing after electron beam welding a electro polished inner conductor and a window.
2. ultra-pure water rinsing
3. ozonized water rinsing
4. ultra-pure water rinsing
5. dried by N_2 gas
6. evacuated at test stand

The outer conductors were electro plaited by Cu using piro-phosphoric acid. And rinsed with pure water and sieled with N_2 gas. And

1. ultra pure water rinsing
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5. evacuated at test stand.

The inner conductor and the outer conductor tested at test bench up to 450 kW. The tested couplers were set at the cryostat using clean hut with small moving mechanism.

3 BIAS AGING

Before cooling down the cavities, we conditioned the input coupler up to 300 kW with full reflection condition, and up to 300 kW with DC bias voltage applied to the inner conductor up to $\pm$ 2kV. This conditioning decreased the secondary electron emission coefficients of the inner and outer conductors and the ceramic window to less than or nearly equal to one. During this room temperature conditioning, the disrobed gas was evacuated to the vacuum ion-pumps. The multipactor around the input coupler, which is known to induce break down of the superconducting cavity during high power beam operation, was strongly reduced. By doing this the cavity could be operated at high power without beam processing of the input coupler. Figure 2 shows the vacuum activity at a given power that resulted from at bias processing.
When we applied DC bias voltages to the inner conductor up to $\pm$ 2 kV, on the starting at a bias voltage of +100 V , we observed light emission near the window on the test stand.(4) As the bias was increased throughout the range, many out gassing events were observed, as shown in figure 2.

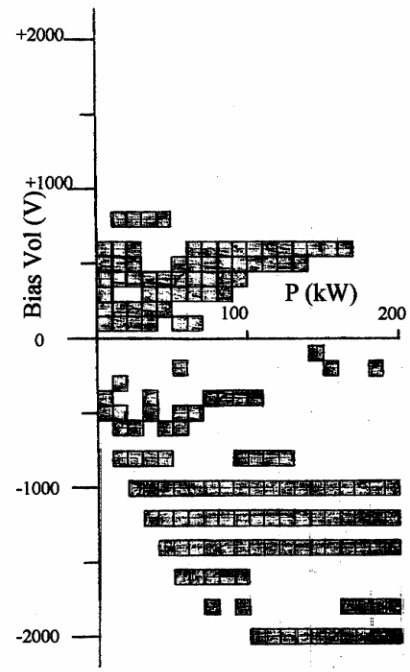

Figure 2: RF processing with bias voltage. Filled boxes show increasing vacuum pressure, which indicates multipacting is occurring.

4 COUPLER OPERATION WITH BEAM

After the liquid helium vessel is filled to about 90 %, we try to raise the coupler power to 300 kW in an off-resonance condition, and raise the cavity voltage , Vc, up to 3 MV which corresponds to 12 MV/m or till breakdown(quench) occurs. Then we shift the phase of cavity up to $\pm$ 30so that the field profile in the coupler changes in order to check and condition the less-conditioned parts of the coupler. Usually, no or slight out gassing is observed during this phase change conditioning. Conditioning at low temperature might be a source of gas condensation at the input coupler and superconducting cavity, so for the stable operation of coupler, the room-temperature bias conditioning is important. A more detailed study for this problem is being done.
The couplers handled RF power up to 380 kW to the beam with a beam current of 0.5 A. This is the highest power record for continuous operation in the world to date. Figure 3 shows the power transferred to the beam and the beam current. The maximum total power transferred to the beam was 1.4 MW by the 4 superconducting cavities.

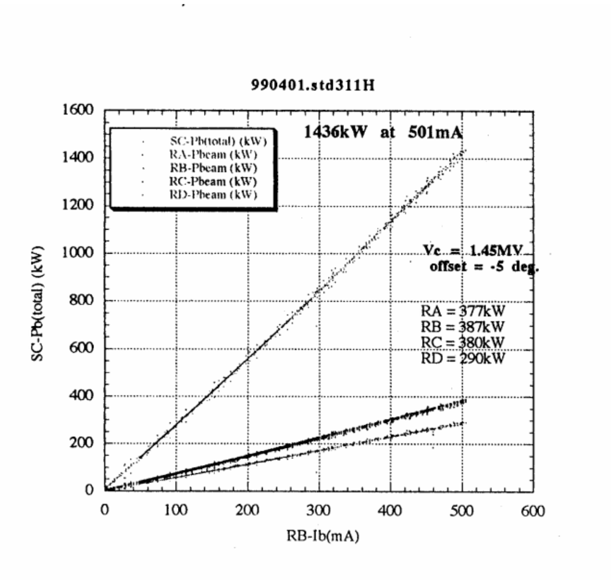

Fig.3 Power transferred to the beam and beam current.

5 SUMMARY

The high power input couplers for KEKB have been operated stably with high current beam. The RF processing with bias voltage is effective to reduce multipacting. The study to understand this mechanism will be continued.

6 REFERENCES

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